Fabrication, Testing, and Analysis of a Flow Boiling Test Facility With Jet Pump and Enhanced Surface Capability

Project Number: 96-06

Investigators: **P.L. Hunt/ED63**

J.B. Holladay/ED62
M.Y. Gard/ED62
K.E. Horton/ED53

Purpose

The purpose of this work is to investigate jet pump technology and the development of a two-phase, flow boiling test facility. Design and fabrication of the test facility is required for evaluation of jet pumped thermal control systems and evaluation of two-phase heat exchanger performance under conditions applicable to aerospace applications.

Background

Evolution of spacecraft, satellites, etc., requires more efficient thermal control systems. Two-phase systems have been shown to offer many advantages over single-phase and passive thermal designs. A potentially highly efficient two-phase cooling system incorporating a jet pump has been studied for aerospace use.[1] The system offers many advantages including minimal electrical power requirements, high reliability, and minimal vibration.

Approach

The initial phase of the project involved various research including: investigation of previous research;[1] development of an alternate means of predicting jet pump performance; and development of test hardware requirements. The final phase of the project, the flow boiling test facility, supports thermal-related aerospace research by providing the ability to evaluate a multitude of thermodynamic cycle configurations and a wide range of thermodynamic states for various candidate heat transfer components.

Accomplishments

Over the past year, the primary effort has involved planning, design, procurement, and assembly of the test facility. Research activities have included: 1) refinement of the jet pump differential model;[2] 2) development of a simplified model[3] for incorporation into a fluid flow network analyzer; 3) design analysis of the R113 boiler;[4] and 4) assessment (and subsequent procurement) of a myriad of potential test hardware. The design of the loop was based on initial analyses completed in the previous year along with continuing refinement in the current year. Progress on the test facility (shown schematically in fig. 48 and pictorially in fig. 49) can be summed up in terms of the major components in the test loop boiler, accumulator, water-glycol heat exchanger, diaphragm pump and manifold. All major components of the R113 loop have been installed onto the test rig (which was salvaged from surplus storage) with the exception of the jet pump which is in fabrication (with four of the eight segments complete). The test refrigerant, trichloro-trifluoroethane (R113), has been procured. Purchase and use of the R113 required EPA refrigerant-handling certification.

Planned Future Work

In the near term, the jet pump will be completed (depending on shop priorities) and integrated into the R113 loop. Following installation of the sensors and data acquisition system, the R113 loop will be essentially complete. The loop will then be leak checked and charged for testing. Results of the jet

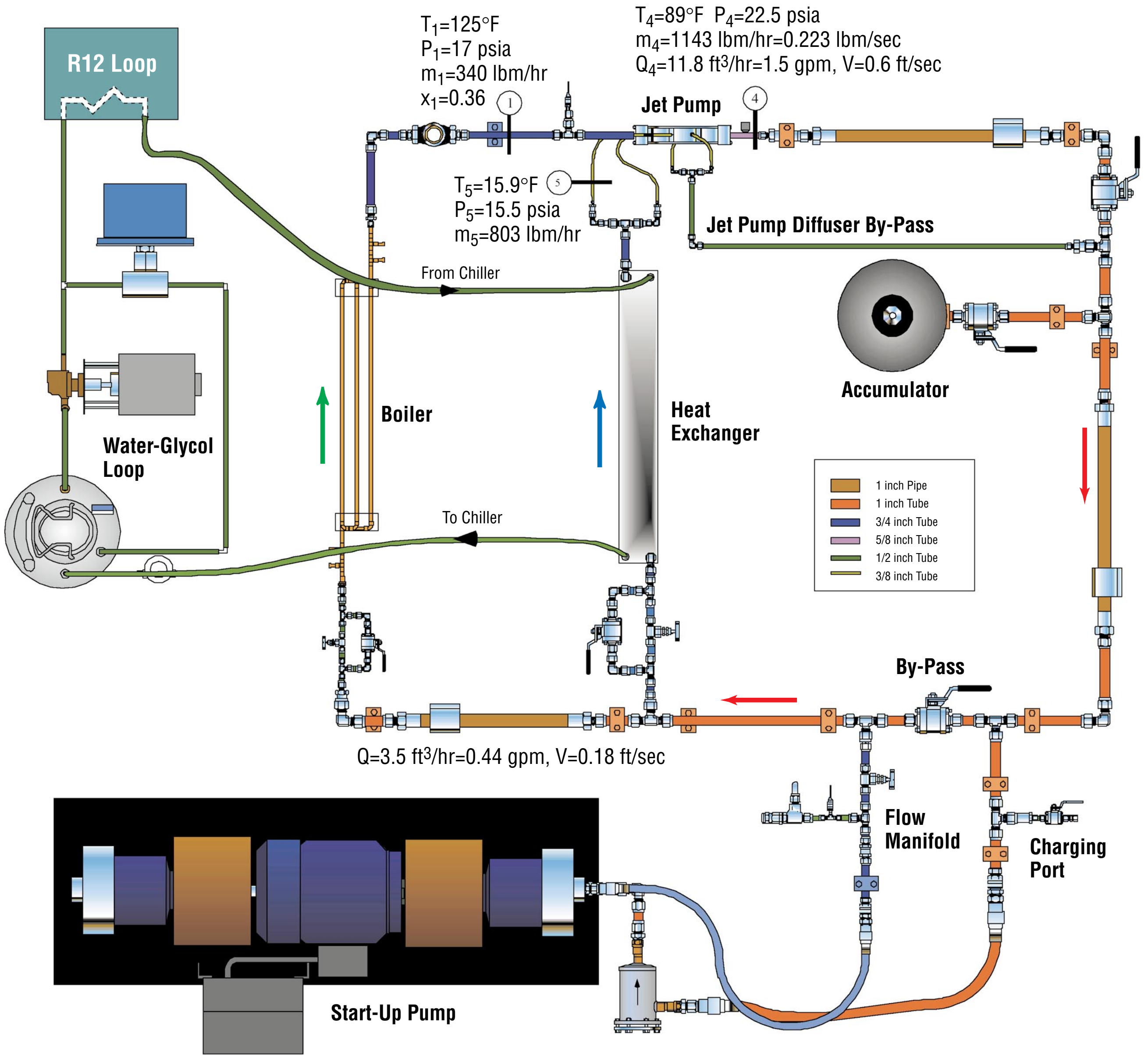

FIGURE 48.— CDDF flow boiling facility schematic.

pump tests will be assessed against existing models and published in the final CDDF report. If the results of the jet pump experimentation prove promising, continued research including additional ground-based testing, proposed on-orbit testing, and additional analytical modeling will be proposed. After jet pump testing is complete, the facility will be transitioned to a more generic flow boiling test facility (with jet pump testing capability) for supporting development of future two-phase TCS systems.

Publications and Patent Applications

Reference 1 has been accepted for presentation at the 1998 AIAA Aerospace Sciences Conference in Reno, NV. An extended abstract[5] has been submitted to the Thirteenth U.S. National Congress of Applied Mechanics.

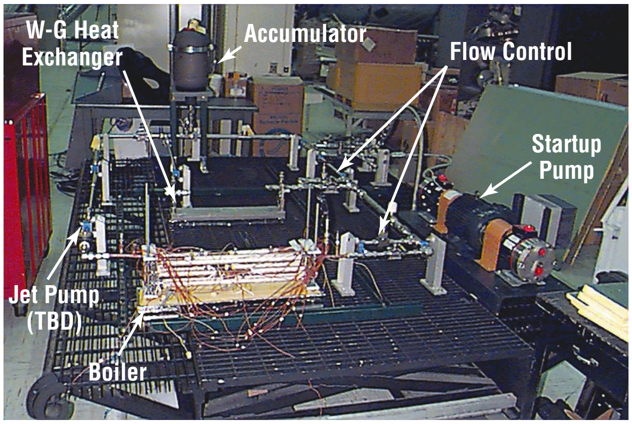

FIGURE 49.—R113 flow loop.

Funding Summary ($k)

The project was authorized by letter on October 17, 1995.

	FY96	FY97
Obligated:	56,825 *	
Obligated:		44,100 **
Unprocessed balance:		2,575.

* including 8k for summer faculty
** including 3.5k for NASA Academy

Status of Investigation

Project approval was in October 1995. Completion is expected in November 1998. No additional funding is requested. All required hardware has been procured. The unprocessed balance of $2,575 is expected to be placed on a credit card for contingencies.

References

[1] Fairuzov, Y.Y.; and Bredikhin, V.V.: "Two-Phase Cooling System with a Jet Pump for Spacecraft," *Journal of Thermophysics and Heat Transfer*, Vol. 9, No. 2, 1995.

[2] Sherif, S.A., et. al.: "Analysis and Modeling of a Two-Phase Jet Pump of a Thermal Management System for Aerospace Applications," 1998 AIAA Aerospace Sciences Conf., 1998.

[3] Sherif, S.A.: "Modeling of a Two-Phase Jet Pump with Phase Change, Shock Waves and Temperature-Dependent Properties," NASA Summer Faculty Final Report, 1997.

[4] Stoddard, N.R.: "Boiler Design for CDDF Project," NASA Academy Final Report, 1997.

[5] Sherif, S.A., et. al.: "Analysis of Two-Phase Flow in Jet Pumps: Effects of the Fabri Condition and Condensation Shocks," Thirteenth U.S. National Congress of Applied Mechanics, 1998.